THIRD LAKE WASHINGTON BRIDGE

Design Criteria - Floating Structure

Loads

D	=	Dead Load (Includes anchor cable initial force)
H	=	Hydrostatic Pressure (at still water draft)
L	=	Live Load (Highway or Rapid Transit Alternate)
I	=	Live Load Impact
WN	=	Normal Wind on Structure - 1 Year Storm
NW	=	Normal Wave - 1 Year Storm
WS	=	Storm Wind on Structure - 100 Year Storm
SW	=	Storm Wave - 100 Year Storm
WL	=	Wind on Live Load
LF	=	Longitudinal Force from Live Load
S	=	Shrinkage and Creep
T	=	Temperature
EQ	=	Earthquake
K	=	Change in Lake Level
DM	=	Force from Loss of Buoyancy in Any Two Adjacent Pontoon Compartments or Force From Loss of Any One Anchor Line or Force From Small Vessel Collision

or

Force from Flooding all Cells Across the Pontoon or Flooding all Cells at Lateral Cable Wall

Note: Streamflow, drift, and ice are considered negligible in Lake Washington

Basic Structural System

Pontoons are reinforced concrete of cellular construction, prestressed longitudinally except the roadway slab is prestressed transversely only. All pontoons are rigidly connected by bolted joints so that the entire structure is continuous. Vertically and torsionally the structure is considered a beam on elastic foundation. Horizontally the structure is considered a continuous beam with elastic supports (cables anchored to the lake bottom.)

Load Combinations

Group	Loads	% of Basic Allowable Stress
I	D+H+L+I+K	100 [L]
II	D+H+WS+SW+K	125

III	Gr.I+WN+NW+WL+LF	125	[L+ WIND/WAVE]
IV	Gr.I+T+S	125	[L+ TEMP + SHRINKAGE]
V	Gr.II+T+S	140	
VI	GrIII+T+S	140	[L+ WIND/WAVE + TEMP & SHRINKAGE]
VII	D+H+EQ	133	
VIII	Gr.I+DM	140	[L+ DAMAGE]
IX	Gr.II+DM	150	
X	Gr.III+DM	150	[L+ WIND/WAVE + DAMAGE]

Notes:

1. The design shall be based on behavior at service conditions (Allowable Stress Design) as per 1977 AASHTO Specifications and Interims through 1978, except as modified herein.

2. Basic Allowable Stresses shall be in accordance with AASHTO Specifications using f'_c = 4,000 psi for Class AX, Conc. f'_c = 5,000 psi for Class PC Conc. and f_s = 24,000 psi for Grade 60 Reinforcement, except as follows:

* Allowable Tension in Precompressed Tensile Zone = 0 psi

The non-prestressed reinforcement steel in the bottom slab and exterior walls shall be designed using $f_s = 14{,}000$ psi.

3. a. The ultimate flexural strength of the overall pontoon section computed in accordance with Sec. 1.6.9 of AASHTO shall not be less than:

   (i) 1.3 (D + H + K) 2.17L

   (ii) 1.3 (D + H + WS + SW +K)

   b. The overall pontoon section shall meet the maximum and minimum steel requirements of Sec. 1.6.10 of AASHTO.

   c. Bolted joints connecting the pontoons shall be designed for the load combinations specified herein and shall have ultimate flexural strength not less than the ultimate flexural strength of the overall pontoon section.

4. The anchorage system shall be designed for Gr. II or III loading at 100% of Basic stresses. The anchor cables shall have an ultimate strength factor of 2.0 min. for WS + SW + K and 1.33 min. for EQ. The anchors shall have a factor of safety of 2.0 min. against sliding or ultimate lateral resistance.

5. Exterior longitudinal walls shall be designed for the above group loadings at D + H + DM (force from small vessel collision) at 140% of

basic stresses, assuming hydrostatic pressure for the full height of the wall.

6. Interior walls shall be designed for the above group loadings and for flooding on one side at 140% of basic stresses. Also the interior walls shall have the ultimate flexural strength to withstand a 100% impact due to rushing water at the equilibrium water level using a F.S. of 1.1 and to withstand for full height flooding on one side of the wall using F.S. of 1.1.

Description of Loads

Dead Loads

Reinforced concrete unit weight shall be taken initally as 160 lb./cu. ft. (including reinf.) for computing dead load stresses and draft. As the design progresses, adjustments will be made based on a concrete weight of 152 #/c.f. plus actual weight of the reinforcing steel and prestressing steel required.

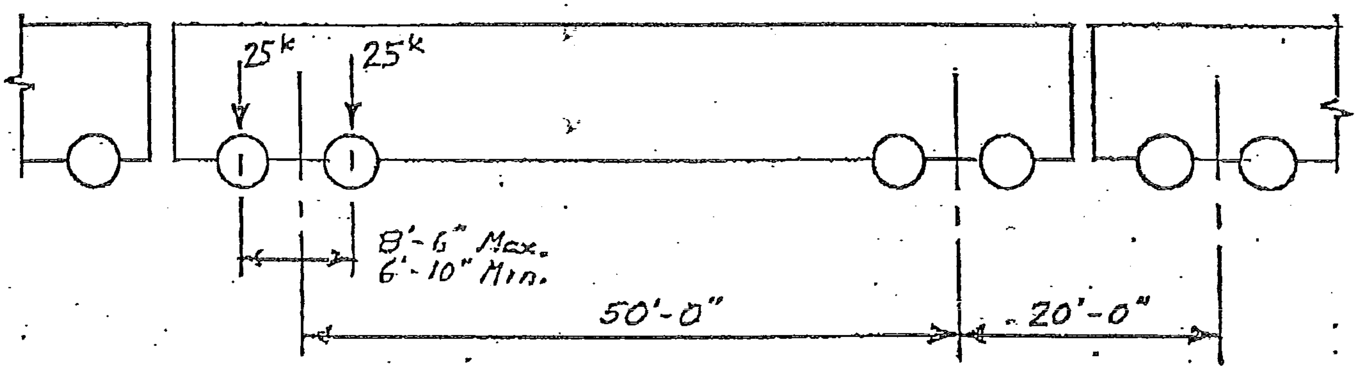
The vertical component of initial cable load may be considered as a dead load. Variations in the cable load due to displacements from other loadings will be included in the effect of each loading, if significant.

* Use HS 25 Live Load

Live Load

HS 20 Truck or Lane Loading shall be used without modification. Military Loading of 2-24 kip axles at 4' centers shall also be considered.

The reversible lanes shall also be designed for the Rapid Transit Loading of the Puget Sound Governmental Conference Rail Rapid Transit Design Criteria shown below.



Car Length	70'
Car Height	12' Max
Car Width	10'
Speed on Bridge	45 mph
Axle Load	25 kips
Impact	$\frac{100\ LL}{DL + LL}$ 30% Max
Lane Width	14' Min.
Traction Force	15%
Wind	300 lbs per lin. ft. of train
Rail Weight	100 lbs per yard

Acceleration and Deceleration Rate	3.5 mph/sec Max.
Number of Cars per Train Unit	8 Max.
Number of Trains on Bridge at Same Time	2 - 1 in each direction
Allowable Grade	5% Max.

Rapid Transit Loading shall be used in combination with the Highway Loadings, considering each track of Rapid Transit as a lane for use of the multiple lane reduction factor.

In addition to Section 1.2.9 of AASHTO Specifications, 60% of the resultant live load stresses shall be used when produced by loading 6 or more traffic lanes simultaneously. (Ontario Code)

Under towing and construction conditions, the top slab of roadway pontoons shall be adequate to take an H-10 loading.

Under the elevated roadway, the top slab of the pontoon shall be designed for a single H-10 maintenance truck.

Live Load Impact

Impact shall be applied in computing local stresses in the roadway slabs and superstructure only, not for overall pontoon stresses.

Wind and Wave - General

Wind blowing over water generates a sea state that induces horizontal, vertical and torsional loads on the bridge structure. These loads are a function of the wind velocity, wind direction, wind duration, fetch (distance over water along which wind blows) and the channel configuration and depth. The bridge shall be designed for the combined effect of wind and wind driven waves, both perpendicular and skew to its longitudinal axis and assuming the First Lake Washington Bridge is not in place. Consideration shall be given to the normal storm and extreme storm wind and wave conditions as indicated in the load combinations. The normal storm conditions are defined as the storm conditions that have a recurrence interval of 1 year (i.e. the maximum storm that is likely to occur once a year). The extreme storm conditions are defined as the storm conditions that have a recurrence interval of 100 years. The 100 year storm conditions are shown in the following table.

Wind Direction	Wind Speed, mph. 10 sec.*	1 min.	1 hr.	Storm Heading (Azimuth)	Fetch in Naut. mi.	Significant wave height ft.	Significant wave period sec.
North	49	45	37	0-30°	6.5	3.04	3.62
				30°-60°	2.5	2.55	2.91
				60°-90°	negligible		
				270°-0°	negligible		
South	66	69	50	90°-120°	negligible		
				120°-180°	2.5	2.55	2.91
				180°-270°	negligible		

* 10 Second gust speeds were determined by multiplying 1 hour mean by 1.31.

100 YEAR STORM CONDITIONS

Wind Force on Structure

Each member shall be designed for 30 psf on the exposed height of pontoon and superstructure plus one traffic barrier height, applied normal to the longitudinal axis.

The overall pontoon section shall be designed for 10 second gusts of 49 miles per hour from the north or 66 miles per hour from the south for Groups II, V and IX loadings and 36 miles per hour from the north or 55 miles per hour from the south for Groups III, VI and X loadings.

A separate longitudinal wind force of 28% of the transverse force shall be used.

An upward overturning force shall be applied to the superstructure per AASHTO Specifications.

Wind Force on Live Load

Use 60% of the AASHTO Specifications values for highway loading. For Rapid Transit Loading use 25 psf on the train area exposed above the rail base.

Waves

The sea is composed of waves from all different directions and are of various heights and frequencies. For a frequency domain analysis, the sea state is defined by a directional wave power spectral density function, formed as the product of a unidirectional wave spectrum and a spreading function. The wave spectrum relates wave energy to frequency. The area under the spectrum is related to the total energy of the sea state. In Lake Washington, the energy density spectra are of the JONSWAP form, as described in Section 2.3.3 of Hood Canal Bridge Replacement Design Criteria Manual by Parsons Brinckerhoff/ Raymond Technical Facilities, Apr. 1980.

The inertial and drag forces induced by the waves impacting on the cross section may be determined by any wave theory that accurately represents its hydrodynamic behavior. The effect of the motion of the structure when impacted by the waves must be considered. Also, diffraction theory must be used to account for the influence of the pontoon on the sea state.

Superstructure pontoons shall be analyzed for stability as individual units under towing conditions.

Temperature

A temperature differential between various portions of the structure shall be considered as follows:

From submerged portion to exposed portion ± 35°

From submerged portion to shaded portion ± 25° F

From shaded portion to exposed portion, ± 25° F

The submerged portion is the entire pontoon except top slab. The shaded portion is the top slab of pontoon beneath the elevated roadway. The exposed portion is the roadway slab, either on the elevated roadway or on the pontoon.

The temperature differential is the difference between average temperature of the various structural portions.

For a longitudinal temperature analysis of the structure the top slab may be considered as a cracked section when it is in tension.

Shrinkage

Differential shrinkage shall be considered between the top slab and lower portion of the pontoon. The ultimate differential shrinkage strain shall be 0.0003.

Pontoon superstructures shall be designed for a differential shrinkage strain of .0002.

Longitudinal Force from Live Load

Per AASHTO Specifications, or Rapid Transit Criteria. In applying the AASHTO Specifications the load used shall be the HS 20 Lane Loading for 1000 ft. of the structure, then reducing linearly to HS 15 Lane Loading in 500 feet, and the remaining structure shall be loaded with HS 15 Lane Loading. 5 lanes shall be used.

Change in Lake Level

Maximum Rise = 0.8 feet.
Maximum Fall = 3.8 feet.

Earthquake

The design shall consider the effects of earthquake generated forces on the structure and the anchorage system.

Potential Damage

Damage to the floating portion of the structure could occur from a collision with a boat, from severing of an anchor line or from other unforeseen accident. Damage to the pontoon bottom slab or exterior wall could result in loss of buoyancy locally. Thus, forces arising from the loss of buoyancy of any two adjacent cells, the flooding of all cells for the width of the pontoon, the flooding of the ten small cells near the lateral cable wall or forces from the severing of any one anchor line shall be considered during normal operating and storm conditions.

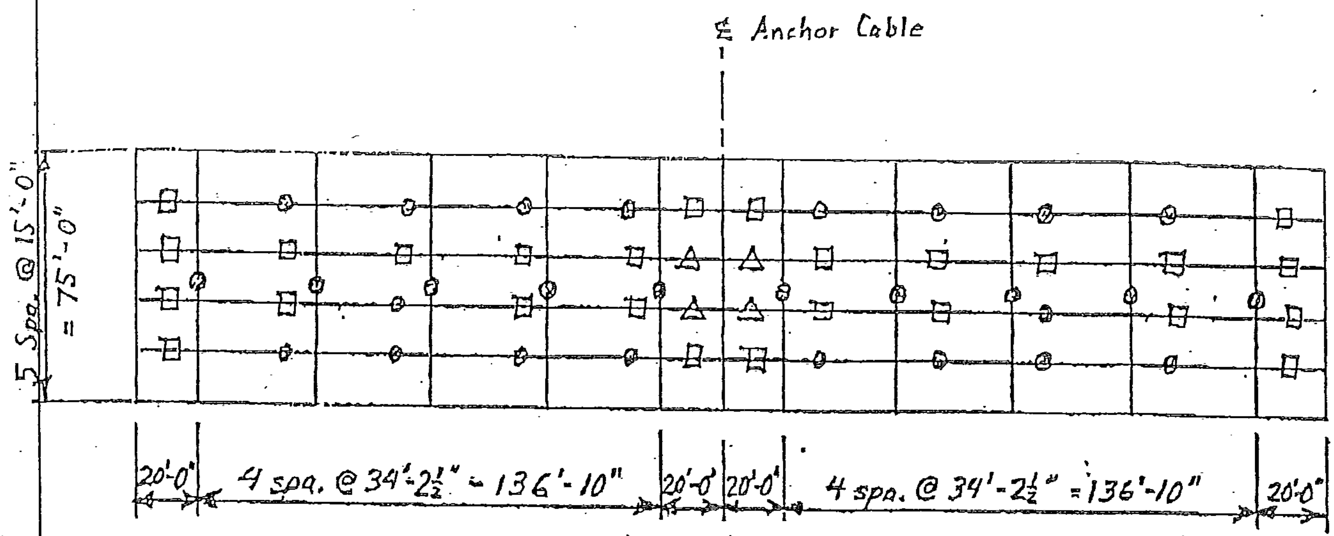
In addition, the flooding of the five end cells of an isolated pontoon under towing or construction condition shall be considered.

In designing the pontoon exterior walls, apply 10 kips horizontal collision load as a service load at the center of the exterior wall panel. However, the exterior wall panel shall have an ultimate strength capacity to withstand 30 kips.

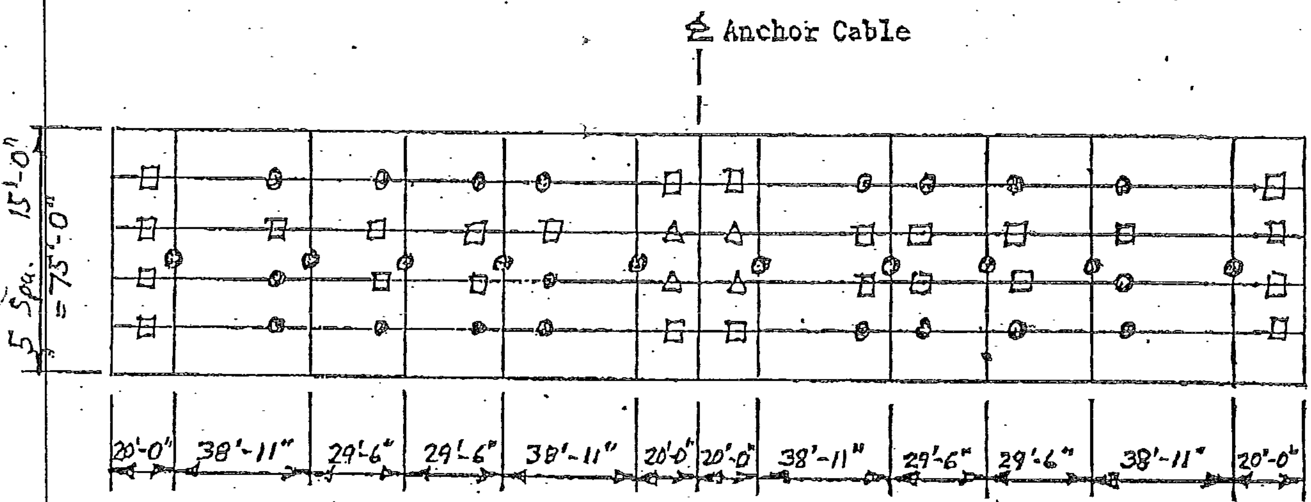
Interior Wall Location and Wall Openings

Provide sufficient interior walls, watertight doors and freeboard on wall openings to withstand potential damages previously mentioned without resulting in a progressive failure.

The wall spacing and watertight door location to meet this criteria is shown as follows.



Pontoons F-I & K-O



Pontoon J

Denotes wall opening between cells with 2'-3" freeboard

Denotes wall opening between cells without freeboard

Denotes wall opening between cells with watertight door and 1'-1" freeboard

Reinforcing Steel Cover

Concrete cover at the face of any reinforcing steel bar shall be 2½" min. at the top of the roadway slab, 1½" min. at the outside face of the exterior walls and bottom surface of the bottom slab, and 1" min. at all other locations. The clearance at the top of the roadway slab includes a 1½" concrete overlay.

Freeboard

The roadway pontoons shall provide a minimum freeboard of 7'-6". The superstructure pontoons shall provide a freeboard of 7'-0". The freeboard shall be measured from the top of the deck at the edge of the slab to the normal water level. The freeboard shall be calculated based on the following criteria.

a) The concrete weight shall be taken as 152 p.c.f. plus the weight of the prestress and reinforcing steel involved.

b) There shall be no live load on the pontoon.

c) The vertical component of the anchor cable force shall be considered as dead load.

d) The weight of catwalk, ladders, and other hardware shall be included.

e) The unit weight of water is 62.4 p.c.f.